ANTI-MICROBIAL FABRICS, GARMENTS AND ARTICLES

Cross-Reference To Related Applications

1) The present application is a division of Serial No. 09/565,138 filed May 5, 2000, and which claims the priority of the following provisional applications: Serial No. 60/136,261, filed May 27, 1999; Serial No. 60/172,285 filed December 17, 1999; Serial No. 60/172,533 filed December 17, 1999; Serial No. 60/173,207, filed December 27, 1999; Serial No. 60/180,240 filed February 4, 2000; Serial No. 180,536 filed February 7, 2000; and Serial No. 60/181,251 filed February 9, 2000, the entire content of all such applications being incorporated herein by reference.

Field of the Invention

2) The present invention relates generally to anti-microbial articles, and, more particularly, to fabrics, fabric construction (having qualities imparted to it which remain for the life of the fabric, such as excellent color fastness without the need for a dye bath), garments and athletic wear and other articles which have anti-microbial properties. This includes garments and similar articles as well as underwear, pajamas, washable and/or disposable diapers, as well as linens, and bed pads, mattress pads or absorbent pads for bed ridden patients, to prevent bed sores. Such garments and articles may be made of woven fabric, knitted fabric or non-woven fabric.

Background of the Invention

3) There are many patents and other forms of published information which are available concerning garments and other articles some of which are intended for use for incontinent persons. Many of these deal with the problem of moving body fluids away from a person's skin to prevent the type of problems created when such fluids remain in contact with the skin for long periods of time, such as rashes and other skin eruptions. Absorbent layers are provided behind the layer which touches the skin.

4) However, there is the danger of infection due to bacterial and fungal growth in urine-soaked fabrics and the overall discomfort caused by wet clothing.

5) There has been little attention to a problem which remains even when the fluids are moved away from the skin. This is the problem caused by microbes which attach to the outer layer which touches the skin even when the fluids move into the absorbent layer. These microbes cause a variety of problems.

6) The University of Minnesota Extension Service, Waste Education Series published an article in 1998, "Infant Diapers and Incontinence Products: Choices for Families and Communities by Gahring et al relating to this subject (hereafter "UOM Article"). This article indicates that the use of disposable diapers and incontinence products have been widely adopted for babies and for adults with certain problems. There is an estimate that there are at least ten million adult Americans who are incontinent. One of the problems is rashes and skin irritation.

7) Moisture absorbing incontinence products are produced in various manners including plastic film or coated nylon for a waterproof backing, paper fiber, gelling material, or cotton gauze; flannel for a middle absorbent layer and nonwoven or woven or knitted fabrics made of polyester, olefin, viscose or cotton for the coverstock.

8) This article discusses health issues for babies relating to the condition of the skin and to the transmission of infectious diseases. Prolonged contact with urine and stool is a major cause of diaper rash.

9) There are environmental problems associated with the large use of disposable products of this type. And this will increase as the number of elderly people in our society increases. While disposables are placed into landfills together with other trash, it appears that many people do not empty the contents of disposables into the toilet, and a study has shown that diaper wastes represent a significant health hazard in landfills. While many such products claim to be biodegradable, this is not always correct and there is some difficulty in making the moisture impervious layers of the plastics used in such products, biodegradable.

10) Also it has been found that super-absorbent disposable diapers are more effective than cloth diapers with separate waterproof pants/wraps. The transmission of infectious disease is a major concern for care, outside of the home. The fecal containment of disposable diapers is found to be significantly better than that of cloth diapers with plastic pants.

11) Thus, there still exists a need to develop garments and articles of the type described which are made of fibers having metal-containing anti-microbials that do not cause the development of resistant bacterial strains for incorporation into fibers that are used to make a variety of fabrics. There also still exists a need for these anti-microbial agents to be resistant to being washed away, thus maintaining their potency as an integral part of the garments and articles into which they are incorporated.

12) PETG as used herein means an amorphous polyester of terephthalic acid and a mixture of predominately ethylene glycol and a lesser amount of 1,4-cyclohexanedimethanol. It is known that PETG can be used in polycarbonate blends to improve impact strength, transparency, processability, solvent resistance and environmental stress cracking resistance.

13) Udipi discloses in U.S. Patents Nos. 5,104,934 and 5,187,230 that polymer blends consisting essentially of PC, PETG and a graft rubber composition, can be useful as thermoplastic injection molding resins.

14) Chen et al. in U.S. Patent No. 5,106,897 disclose a method for improving the low temperature impact strength of a thermoplastic polyblend of PETG and SAN with no adverse effect on the polyblends clarity. The polyblends are useful in a wide variety of applications including low temperature applications.

15) Billovits et al. in U.S. Patent No. 5,134,201 disclose that miscible blends of a thermoplastic methylol polyester and a linear, saturated polyester or co-polyester of aromatic dicarboxylic acid, such as PETG and PET, have improved clarity and exhibit an enhanced barrier to oxygen relative to PET and PETG.

16) Batdorf in U.S. Patent No. 5,268,203 discloses a method of thermoforming thermoplastic substrates wherein an integral coating is formed on the thermoplastic substrate that is resistant to removal of the coating. The coating composition employs, in a solvent base, a pigment and a thermoplastic material compatible with the to-be-coated thermoplastic substrate. The thermoplastic material, in cooperation with the pigment, solvent and other components of the coating composition, are, after coating on the thermoplastic substrate, heated to a thermoforming temperature and the thermoplastic material is intimately fused to the thermoplastic substrate surface.

17) Ogoe et al. in U.S. Patent No. 5,525,651 disclose that a blend of polycarbonate and chlorinated polyethylene has a desirable balance of impact and ignition resistance properties, and useful in the production of films, fibers, extruded sheets, multi-layer laminates, and the like.

18) Hanes in U.S. Patent No. 5,756,578 discloses that a polymer blend comprising a monovinylarene/conjugated diene black copolymer, an amorphous poly(ethylene terephthalate), e.g. PETG, and a crystalline poly(ethylene terephthalate), e.g. PET, has a combination of good clarity, stiffness and toughness.

19) Eckart et al. in U.S. Patent No. 5,958,539 disclose a novel thermoplastic article, typically in the form of sheet material, having a fabric comprising textile fibers embedded therein. The thermoplastic article is obtained by applying heat and pressure to a laminate comprising an upper sheet material, a fabric comprised of textile fibers and a lower sheet material. The upper and lower sheet materials are formed from a co-polyester, e.g. PETG. This thermoplastic article may be used in the construction industry as glazing for windows. One or both surface of the article may be textured during the formation of the articles.

20) Ellison in U.S. Patent No. 5,985,079 discloses a flexible composite surfacing film for providing a substrate with desired surface characteristics and a method for producing this film. The film comprises a flexible temporary carrier film and a flexible transparent outer polymer clear coat layer releasably bonded to the temporary carrier film. A pigment base coat layer is adhered to the outer clear coat layer and is visible there through, and a thermo-formable backing layer is adhered to the pigmented base coat layer. The film is produced by extruding a molten transparent thermoplastic polymer and applying the polymer to a flexible temporary carrier thereby forming a continuous thin transparent film. The formed composite may be heated while the transparent thermoplastic polymer film is bonded to the flexible temporary carrier to evaporate the volatile liquid vehicle and form a pigment polymer layer. The heating step also molecularly relaxes the underlying film of transparent thermoplastic polymer to relieve any molecular orientation caused by the extrusion. Ellison also mentions that it is desirable to form the flexible temporary carrier from a material that can withstand

the molten temperature of the transparent thermoplastic polymer. The preferred flexible temporary carriers used in his invention are PET and PETG.

21) Currently, many tee shirts, such as the grey athletic shirts, are made by blending in up to 10% of either solution dyed black polyester or stock dyed cotton. The solution dyed polyester has a disadvantage in that the product can no longer be labeled 100% cotton. The stock dyed cotton has the disadvantage in that it is not color fast, especially to bleach, and that it needs to be passed through a dye bath.

Summary of the Invention

22) The excellent wetting characteristics of PETG can be used to distribute the anti-microbial additive uniformly within a yarn or fabric. In addition to the carrier (e.g. a zeolite) of silver, the PETG could carry ions of other inorganic anti-microbial additives such as copper, zinc, or tin in their respective carriers.

23) In addition to the anti-microbial component, the invention may be used to carry pigments with the PETG to achieve certain colors without the need to dye the other fibers.

24) The created synthetic fibers of polymers and additives can further be blended with non anti-microbial fibers to provide anti-microbial finished fabrics that are able to withstand significant wear and washings and maintain their effectiveness.

25) The use of a cloth diaper and a garment over it is effective, especially when anti-microbial/anti-fungal fibers are used for the fibers which have contact with the waste matter, although beneficial effects are available even when the anti-microbial/anti-fungal agents are used only in the fibers which touch the body.

26) Due to the urine soaking which occurs with incontinent persons, these garments are suitable for the use of anti-microbial and anti-fungal fibers during their manufacture. The use of such anti-microbial material allows these garments to be reusable without the negative effects of present reusable garments of this type. The anti-microbial may be fabric (knitted or woven) plus absorbent pads. This also applies to bed pads, mattress pads or absorbent pads for bed ridden patents to prevent bed sores.

27) It is an object of the invention to provide garments and articles intended for use for incontinent persons which articles have anti-microbial and/or anti-fungal

fibers in a woven or non-woven fabric of the garment or article which is in contact with such person's skin to eliminate or substantially reduce the problems caused by such microbes.

28) It is another object of the invention to provide such garments and articles which may be cleaned and reused many times while maintaining the beneficial anti-microbial qualities thereof.

29) It is a further object of the invention to provide anti-microbial fibers in the absorbent material usually used in such articles.

30) The present invention provides an anti-microbial finished fabric by blending the synthetic anti-microbial fibers with non-anti-microbial fibers such as cotton, wool, polyester, acrylic, nylon, and the like.

31) PETG is an amorphous binder fiber which can be blended into yarns with other fibers to form fabrics, as well as non-woven fabrics. After heat activation, the PETG fiber melts, wets the surface of the surrounding fibers, and settles at the crossing points of the fibers, thus forming "a drop of glue" which bonds the fibers together and distributes the anti-microbial additives.

32) The excellent wetting characteristics of PETG can be used to distribute the anti-microbial additive uniformly within a yarn or fabric. In addition to the zeolite of silver, the PETG could carry other inorganic anti-microbial additives such as copper, zinc, or tin.

33) In addition to the anti-microbial component, the invention may be used to carry pigments with the PETG to achieve certain colors without the need to dye the other fibers.

34) The created synthetic fibers of polymers and additives can further be blended with non anti-microbial fibers to provide anti-microbial finished fabrics that are able to withstand significant wear and washings and maintain their effectiveness.

35) It is an object of the invention to provide a fabric formed from a fiber to which qualities may be imparted which last for the life of the fabric.

36) It is another object of the invention to provide such a fabric which is provided with coloring which remains fast even to sunlight and many launderings.

37) It is a further object of the invention to provide such a fabric which is provided with a colorant without the use of a dye bath.

38) It is still another object of the invention to provide a fiber and fabric of the type described which possesses anti-microbial properties.

39) It is yet another object of the invention to provide a fiber and fabric of the type described in which characteristics may be imparted using agents which become permanently fixed and are maintained for the life of the fabric.

40) These objects and others are accomplished in accordance with the present invention which uses PETG:

a. As a carrier for pigments for coloration for use in finished fabrics to withstand fading;

b. With pigments together with other fibers, so that the need for conventional dyeing and disposal of dye materials is avoided;

c. With pigments and other fibers, and the resulting fabric possesses excellent fastness for both sunlight resistance and washing;

d. With pigments for coloration, the color of the fabric remains fast for in excess of 50 commercial launderings;

e. With pigments blended with cotton, which leaves the encapsulated pigment attached to the outside of the cotton fiber_and ceases to be a fiber after activation, so that the resulting fabric can still be labeled 100% cotton fiber; and

f. With anti-microbial and/or other additives with any natural fibers, so that the resulting fabrics have anti-microbial and/or other properties with the same characteristics of natural fabrics.

41) PETG may be used as one of the polymer blends and/or carriers for a wide variety of applications. PETG is an amorphous binder fiber that can be blended into yarns with other fibers to form woven fabrics, as well as knits and non-woven fabrics. It has two characteristics of particular interest: (1) excellent wetting and (2) low melting temperature (which can be controlled between 90°C and 160°C). It is used in the present invention as a carrier to carry pigments and/or anti-microbial additives and/or other additives and is blended with other fibers which may be natural fibers such as cotton, silk, flax, wool, etc. or other synthetic fibers such as: PET, PP, PE, Nylon,

Acrylic, etc. After heat activation, the PETG melts, continuously releases the color pigments and/or anti-microbial or other additives and wets the surface of the surrounding fibers with the pigment and/or anti-microbial or other additives it carries. It settles at the crossing points of the fibers, thus forming "a drop of glue" which bonds the fibers together. Therefore, PETG delivers and distributes the pigments and/or anti-microbial or other additives uniformly within a fabric, generating the finished fabrics and/or fabrics having anti-microbial properties.

42) Since the natural fibers used to blend with PETG are not changed physically after heat activation of PETG, they contain the same characteristics as natural fibers. The PETG may be used together with or without anti-microbial agents to form a fabric having excellent color fastness even in the presence of sunlight, and will withstand many washings without deterioration. The fabric is made by blending PETG used as a carrier for pigments and/or anti-microbial additives, with cotton or any other fibers of synthetic material such as from polyester and rayon, and activating PETG from 110° to 140° C. The color is thus provided to the yarn and fabric without the need of going through a dye bath. This fabric remains color- fast for in excess of 50 commercial launderings.

43) The excellent wetting characteristics of PETG can be used to distribute the pigments and/or anti-microbial additive uniformly within a yarn or fabric. While many anti-microbial agents may be used, such as those, which use copper, zinc, or tin, the preferred agent is zeolite of silver. In addition to the anti-microbial component and the pigment added to the PETG, the PETG may be used as a carrier to add other properties to yarn and fabric, such as fire retardants.

44) Other objects, features and advantages will be apparent from the following detailed description of preferred embodiments taken in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

45) FIGS. 1A, 1B, 1B', 1B" and 1C are cross-sectional views of various fiber configurations used in practice of the various embodiments of the invention.

46) FIG. 2. is a sketch of a fibrous mass using one or more of the fibers of FIGS. 1A-1C.

47) FIG. 3 is a schematic view of the feed hopper, screw and extruder.

48) FIG. 4 is a sectional view through the exit of the extruder showing the formation of coaxial bi-component fibers of the present invention.

49) FIGS. 5 and 6 are photomicrographs of fibers showing the particles of zeolite of silver.

50) FIG. 7 shows a garment made from the fibers of the present invention for a person who is incontinent.

51) FIG. 8 is a cross section of one type of filter using the fibers of the present invention.

52) FIGS. 9A, 9B, 9C, 9D are diagrams of air flow systems utilizing the fibers of the invention.

53) FIG. 10 is a cross section of one type of wound care or burn dressing.

54) FIG. 11 is a flow chart showing the preparation of the fibers and yarn for use in making a woven or nonwoven fabric.

55) FIG. 12 is a flow chart showing the preparation of fibers and yarn and then of a fabric.

56) FIG. 13 is a flow chart showing another manner of preparing fibers in accordance with the present invention.

57) FIG. 14 is a schematic isometric view of a first type of insole using latex.

58) FIG. 15 is a schematic isometric view of a second type of insole using a layer of anti-microbial fibers.

59) FIG. 16 is a side view of a sheet material having an anti-microbial film layer co-extruded thereon.

60) FIG. 17 is a side view of a sheet material having two anti-microbial films extruded thereon, one on each side.

61) FIG. 18 is a side view of a further arrangement in which a double sheet material is complete surrounded by an anti-microbial film.

62) FIG. 19 is a side view of a shaped sheet material having two anti-microbial films extruded thereon.

63) FIG. 20 is an isometric view of a food tray constructed in accordance with the present invention.

64) FIG. 21 is a partial sectional view of apparatus for making a multi-layer co-extruded sheet.

65) FIG. 22 is a sectional view through the apparatus shown in FIG. 21.

66) FIG. 23 is an isometric view of apparatus for making a side-by-side co-extruded sheet.

67) FIG. 24 is a cross section through an insole made in accordance with the present invention.

68) FIG. 25 is a plan view of the insole of FIG. 24.

69) FIG. 26 is a cross section through a laminate for footwear components.

70) FIG. 27 is a cross-sectional exploded view through an office partition.

71) FIG. 28 is a schematic view of a humidifier evaporation surface media used to humidify air.

72) FIG. 29 is a schematic view of a humidifier pad or filter in a system.

73) FIG. 30 is a pad or filter for a circulation/aeration system.

Detailed Description of the Preferred Embodiments

74) The following non-limiting examples illustrate practice of the invention for fabrics and other articles including the making of the fibers therefor.

<u>Example 1</u>

75) The anti-microbial fiber of the present invention was used in the making of a mattress pad. In this example, 15% of a 6.7 denier 76mm cut length natural white fiber was used as a homofilament with zeolite of silver as the anti-microbial agent and 15 % of a bi-component fiber was used together with 70% PET 6x3 T295 in a blend in which the zeolite of silver comprised 0.9% of the fiber. The blend of this fiber was made into a batt of about 1-1 1/2 " thickness of nonwoven material which was then placed between two layers of woven fabric to form a mattress pad. When tested using the shake flask test this provided a 99.99% microbial kill ratio.

76) There are other examples in which all of the parameters of Example 1 were used and in each of which there was 15% of a bi-component fiber used. Again the zeolite

of silver comprised 0.9% of the fiber. The percentage of the anti-microbial fiber ranged from 20% to 40% and the PET ranged from 45% to 65%. In all examples the microbial kill ratio was 99.99% using the shake flask test.

Example 1A

77) In this example, 35 % of a 6.7 denier 51mm cut length natural white fiber was used in a sheath/core bi-component configuration with zeolite of silver as the anti-microbial agent and 15% of another bi-component fiber was used together with 50% PET 6x3 T295 in a blend in which the zeolite of silver comprised 1.8% of the fiber. The blend was then prepared as in example 1 and when tested using the shake flask test, there was a 99.9% microbial kill ratio.

78) A second group similar to the first one was prepared in which the sheath/core bi-component fiber with zeolite of silver as the anti-microbial agent comprised from 10 to 35% of the fiber blend, 15% of another bi-component fiber was used and from 50 to 75% of PET 6x3 T295 was used. The zeolite of silver comprised 0.75% of the fiber. In the shake flask test, there was a 99.99% microbial kill ratio.

Example 2

79) In this example, 15% of a 3.5 denier 38mm cut length PETG fiber was used as a homofilament with zeolite of silver as the anti-microbial agent. 85% PET fiber was blended with the PETG anti-microbial fiber to form a blend in which the zeolite of silver comprised 1.8% of the fiber. The fiber was made into a wall covering and was tested by the shake flask test, which provided a microbial kill rate of 99.99%

80) A modified version was prepared the same way except that there was only 10% fiber with zeolite of silver in the blend and 90% PET fiber was used. After the fiber was made into a wall covering, this too provided a 99.99% microbial kill rate using the shake flask method of testing.

81) A further modified version was used in which there was only 5% fiber having zeolite of silver in the blend and 95% PET fiber in the blend. The testing, after the fiber was used in a wall covering, again provided a 99.99% microbial kill rate for bacteria.

82) The fibers described above can be used to make both woven and nonwoven fabrics as well as knitted fabrics. Such fabrics are useful for various types of articles, some of which are listed below:

83) Incontinent garments, including disposable diapers, underwear, pajamas, and linens, some of which may be knitted. This is disclosed, for example, in pending provisional application Serial No. 60/173,207 filed December 27, 1999, the contents of which are physically incorporated herein below, in which garments and other articles for incontinent persons made of an anti-microbial fiber comprises various thermoplastic polymers and additives in a mono-component or bi-component form in either a core-sheath or side-by-side configurations. The anti-microbial synthetic fibers can comprise inorganic anti-microbial additives, distributed only in certain areas in order to reduce the amount of the anti-microbial agents being used, and therefore the cost of such fibers. The anti-microbial additives used in the synthetic fibers do not wash off over time because they are integrally incorporated into these fibers, thus their effectiveness is increased and prolonged. The anti-microbial synthetic fibers comprise high tenacity polymers (e.g. PET) in one component and hydrolysis resistance polymers (e.g. PCT) in another component. The hydrophilic and anti-microbial additives provide a hydrolysis-resistant surface with good wrinkle resistance that results in long-term protection against washings in boiling water and strong soaps. The anti-microbial synthetic fibers can further be blended with non-anti-microbial fibers such as cotton, wool, polyester, acrylic, nylon etc. to provide anti-microbial finished fabrics that are able to withstand significant wear and washings and while maintaining their effectiveness. The invention further comprises a method for making a fiber blend which includes mixing a polyester polymer, characterized by a low melting temperature and having binder qualities, with an additive for providing desired characteristics to a finished fiber. The mixture is heated and extruded to form a continuous filament. The continuous filament fiber is cut to form a cut filament fiber. The cut filament fiber is blended with a natural fiber to form a fiber blend. The fiber blend is heated to a temperature in the melting temperature range of said polyester polymer for a sufficient period of time to melt the low melting temperature polyester polymer and wet the natural fiber and provide such natural fiber with the additive firmly attached thereto. The polyester polymer may be PETG. After the fiber is

prepared it may be spun to make a yarn and the yarn may be made into a fabric. The heating step can take place after the yarn is made into a fabric. The additive may be a colorant, an anti-microbial agent, a fire retarding agent, or another agent which adds properties to the fiber or yarn or fabric. There is another method for making a fiber, which includes mixing a polyester polymer, characterized by a low melting temperature and having binder qualities, with an additive for providing desired characteristics to a finished fiber, heating the mixture and extruding it to form a continuous filament. Another polymer is heated and extruded to form a continuous filament. The extruding steps form a bi-component fiber with the mixture forming the sheath and the other polymer forming the core. The sheath is heated to a temperature in the melting temperature range of the polyester polymer for a sufficient period of time to melt the low melting temperature polyester polymer and wet the core fiber and provide the core fiber with the additive firmly attached thereto.Office partition and office component fabrics can be made in accordance with the present invention. An example is shown in FIG. 27 which is a cross section through an office partition in which there is a multi-layer partition having a filling layer 240, a fabric layer 242 on one side and a third layer 244 which may also be of fabric or can be of a solid material. Office type partitions walls can be portable or semi-portable dividers of open area for personnel work stations and other assigned work and waiting areas for employees and clients. The fiber can be wholly or partly synthetic fibers which is mono-or multi-component and can be used with other synthetic or natural fibers to form a variety of fabrics uses as wall covering and/or wall fillers. Partitions of this type are used in office factory, storage and customer service areas. They are provided with fabric surfaces (woven, knits, or non-woven) for aesthetic reasons, sound absorption and/or to cushion impacts. They may also be divided with internal fabric or loose fiber fills for cushioning, wall covering substrate support and sound and/or thermal insulation purposes. The anti-microbial agent is incorporated into the fibers in one or both of the outer layers 240 and 244. This can include fabrics for office, hospital, waiting area, classrooms, busses, cars, and the like and also curtains, upholstery, carpets and bedspreads. In addition to the anti-microbial agent, other materials can be added to the fibers such as pigments, fire retardants, color fixing agents, and UV resistant agents. Partitions are assembled, disassembled, moved and reassembled

with some frequency. This and traffic around such partitions creates an environment for spread of airborne or contact transmitted disease, and partitions are frequently touched. This invention provides partition systems and other articles of the type described. An anti-static agent can be added to assist in dissipating static charges which create problems, for example, when computers are being used. The product remains intact when subjected to normal cleaning and can be assembled by being needle punched, resin bonded wet laid, thermo-bonded, and spun bond. In office environments there is the spillage of food and spills from office supply and janitorial materials and simple hand contact on wall surfaces. These and other environmental insults have the potential to leave residues that can be good substrates for the growth of bacteria, mold and other microbes. They can be in moist environments and the partitions are site for growth, and also from airborne microbes.Athletic wear clothing and liners, including athletic wear liners made from a wholly or partly synthetic fiber that can be wither mono-or multi-component in nature, and binder fibers both staple and filament, with anti-microbial properties and which can be used with other synthetic or natural fibers to form a variety of fabrics and materials. Athletic wear is subject to the accumulation of bacteria, fungi, and associated odors that can proliferate in the presence of sweat and other bodily secretions that result from strenuous exercise in this type of clothing. This type of product may be made using anti-microbial fibers, and which for some applications are provided with a layer which touches the skin and wicks away the sweat to make a more comfortable garment (or liner) and this type of article benefits from the use of anti-microbial fibers in at least one layer. They can include T-shirts, crotch liners, bicycle pants and shirts, sweat suits, athletic supporters, stretch pants, long underwear, and athletic socks. Because this type of clothing is constantly and intermittently being soaked with sweat and brought into contact with dirt and associated materials, they are subject to bacterial and fungal growth as well as to the development of associated odors. By manufacturing this clothing with lining materials made, at least partially, of the anti-microbial fibers of this invention, growth of microbes could be reduced. In addition, the exacerbation of microbial growth and resultant odor production upon storage of this type of clothing in bags over time could be reduced. These anti-microbial fiber-containing clothing is useful in reducing the growth of bacteria, fungi, and other microbes once

soaked with sweat, thus reducing associated odors and the discomfort of the individual. Specifically, the anti-microbial-fiber containing fabrics may be used in the interior linings of shirts and pants or shorts, such as those used in running and bicycling. These anti-microbial fibers may also be used in the manufacture of athletic clothing that does not have linings. This type of athletic clothing is then able to be used for long periods of time while maintaining its anti-microbial and anti-odor properties because of its resistance to multiple washings. In addition, the methods described above could also be used to produce clothing dyed in a variety of colors that would possesses the characteristics of inhibiting microbial growth and its associated odors, thus increasing its versatility.Anti-microbial fibers can be used to make materials for a variety of applications in which it is necessary or desirable to reduce bacterial and fungal growth and the resultant odor. Specifically, in personal hygiene situations, these materials can be used in reusable or re-wearable incontinent garments and other articles such as linens and bed pads, mattress pads or absorbent pads to prevent bed sores on persons confined to bed for extended periods of time. Diapers and other clothing and articles for incontinent individuals are constantly and intermittently being soaked with urine and these items as now manufactured are not effective at killing odor and infection-causing bacteria. By making these items disposable, the growth of bacteria and fungi is reduced depending upon how often they are changed, but there are environmental and other considerations to disposables. However, the use of the anti-microbial fibers in such garments and articles that maintain their effectiveness during washings, results in reusable garments and articles of the type described with odor reducing and anti-microbial properties which last for the life of such garments and articles.

88) As a result of the above, the use of anti-microbial fibers in the manufacture of incontinent garments is desirable. These anti-microbial fiber-containing garments are useful in reducing the growth of bacteria, fungi, and other microbes once soaked with urine, thus reducing the discomfort of the individual and preventing infections generally. Specifically, the anti-microbial fiber-containing fabrics may be used in both the covering fabric and the water absorbent interior material. In this way, both surface and interior protection is achieved. In addition, these materials may also be made to be reusable because the anti-microbial effect of the fibers of these garments and

articles are resistant to multiple washings. Thus, a significant cost savings is realized in the laundry operations of hospitals and nursing homes as well as in the economics of individual households.

89) In manufacturing these materials, any of the fiber embodiments described below could be used. Both the strength and resiliency of these materials is important since they must stand up to multiple wettings and subsequent cleanings. Thus, both bi-component fibers and mixed fiber fabrics are useful embodiments for incontinent garments. Also, other modifications of the characteristics of these fibers and fabrics beyond that of adding anti-microbial agents, including the addition of agents to increase or decrease hydrophobicity, are useful in view of the repeated wettings and the need for frequent cleanings and washings. In addition, anti-odor additives may be particularly useful in this application in light of this frequency of cleaning, as well as the wetting with urine. Thus, these anti-microbial materials, garments and articles significantly reduce the growth of mold, mildew, and bacteria in home and institutional environments.

90) Garments for incontinent persons are made of anti-microbial fibers designed to use inorganic silver-containing compounds that are integrated into the polymers that are used to make these anti-microbial fibers. However, other metals (such as copper, potassium, magnesium, and calcium) can be used as anti-microbial agents. In addition, mixtures of different metal-containing anti-microbial agents in differing concentrations can be used that result in hybrid agents tailored for specific tasks.

91) Such garments may be knitted or woven and include underwear, pajamas, linens, disposable diapers, and the like.

92) One type of such garment of the present invention is shown in FIG. 7 in which there is a garment 34 which carries a removable liner assembly 36 which is detachably secured within the garment. The liner assembly includes an outer layer 33 which contacts the skin of a wearer 44 around the buttocks and crotch area. This layer is made to be smooth and soft so as to be comfortable for the wearer even when fluids such as urine contact this layer and pass therethrough. There is a wick layer 35 which changes color when it is wet so that attendants can see from a distance that a wearer is wet and needs to receive some attention, such as the changing of the liner assembly.

Beyond the layer 35 is an absorbent layer 31 formed of a mass of fibers. There is an inner layer 37 which is impervious to fluids so that the fluids such as urine do not wet and/or stain the outer layer of clothing. The liner assembly 36 is held together by soft fiber connectors, 38. The liner itself may be removably attached to the basic garment with Velcro so that it is easily removable and changed.

93) The liners 36 may be constructed to be washable so that they can be reused, or can be made to be disposable. The garment has a belt 42 for holding the garment in place.

94) The outer layer 33 is made of anti-microbial fiber of the type described in further detail below so that there is protection from microbes and fungus which causes infection and odors.

95) Layer 33 is made to be a porous fiber material which will draw any moisture from the wearer by wick action away from the wearer's skin and into the absorbent liner. Since the layer 33 is always against the wearer's skin and at least at times is wet from urine, there is the risk of infection which, with the present invention is prevented, due to the layer 33 being constructed of anti-microbial fibers, the construction of which is described in more detail above.

96) The absorbent material 31 of the liner 36 may also be made of non-woven fibrous material which is also anti-microbial if desired.

97) Anti-microbial fibers may be made into other products intended for incontinent persons, such as bed linens, and bed pads, mattress pads or absorbent pads which are used to prevent bed sores in persons who are confined to bed for extended periods of time. Such products provide a first line of attack against problems caused by microbes especially when used in all areas of the products which come into contact with a person's skin.

98) Higher loading of the anti-microbial agents (up to 5 times) is used to more effectively act against fungi. This higher loading may be achieved by using various zeolites followed by heating the fiber polymer, e.g. PET, to between 180 and 230 degrees Fahrenheit in hot water which allows further metal loading or ion exchange to replace resident metal ions with another ion or mixture of ions. In addition, this would allow the zeolite at or near the surface of the fiber to be preferentially loaded with the

metal ion or mixtures thereof that has the desired biological effect. These methods are particularly useful in reducing costs when expensive metal ions, such as silver, are used in these processes. Also, by adding certain metals, e.g. silver, at this point in the process and not having it present during the high temperature fiber extrusion process, any yellowing or discoloration due to oxidation of the metal ion or its exposure to sulfur and halogens would be greatly reduced.

99) Nautical fabrics can be made at least in part using the anti-microbial fibers of the present invention and are particularly useful for this type of application in which the fabrics are constantly wet and subject to mildew.

100) It will now be apparent to those skilled in the art that other embodiments, improvements, details, and uses can be made consistent with the letter and spirit of the foregoing disclosure and within the scope of this patent, which is limited only by the following claims, construed in accordance with the patent law, including the doctrine of equivalents.

101) What is claimed is: